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(54) Title of the Invention: PIXEL ELECTRODE STRUCTURE OF ACTIVE MATRIX LIQUID CRYSTAL DISPLAY DEVICE

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Specification

1. Title of the Invention

PIXEL ELECTRODE STRUCTURE OF ACTIVE MATRIX LIQUID CRYSTAL DISPLAY DEVICE

2. Scope of Claim for Utility Model Registration

(1) A pixel electrode structure of an active matrix liquid crystal display device comprising plural sets of R, G, and B pixel electrodes individually driven by an active element connected to a scanning electrode and a signal electrode, which are perpendicular to each other, wherein one picture element includes one of the sets of the R, G, and B pixel electrodes;

wherein each of the R, G, and B pixel electrodes in each intersection portion of the scanning electrode and the signal electrode is formed to have a shape substantially protruding in a "boomerang" shape in an extending direction of the scanning electrode, and

wherein one active element is provided corresponding to each of the R, G, and B pixel electrodes.

(2) The pixel electrode structure of the active matrix liquid crystal display device according to claim 1, wherein a shift amount in a protruding direction of a protruding portion with the "boomerang" shape of each of the R, G, and B pixel electrodes is set to any value in a range of 0.8 to 1.2 pixel pitch from either edge of each pixel electrode.

3. Detailed Description of the Invention

(Industrial Field of the Invention)

The present invention relates to an active matrix liquid crystal display device, and in particular, relates to a pixel electrode structure of color display thereof.

(Prior Art)

In a conventional active matrix liquid crystal display device, one color picture element is formed in each intersection portion of many

scanning electrodes and signal electrodes which are orthogonal to each other, and one color screen is composed of the picture elements arranged in matrix . Each picture element is normally composed of a set of R, G, and B pixel electrodes, and the R, G, and B pixel electrodes forming one picture element are provided as electrodes having an integral structure. In each of the R, G, and B pixel electrodes, an active element such as a thin film transistor is connected between the pixel electrode, the scanning electrode, and the signal electrode and liquid crystals are driven to display an image.

In this conventional structure, when an image is displayed on a screen by driving liquid crystals, there has been a problem to be solved in that the displayed image is difficult to be seen due to insufficient resolution, generation of moire fringes on the screen, and the like. In Japanese Patent Application No. Sho 62-116978, in order to reduce the apparent resolution to see image display easily, an inventor and the like of the present applicant provide an active matrix liquid crystal display device having a structure in which each of R, G, and B pixel electrodes forming one picture element is segmented into two sub-pixel electrodes and an active element is provided in each sub-pixel electrode.

A color pixel arrangement having this segmented electrode structure is shown in FIG. 2. In FIG. 2, S_3 and S_{3+1} represent scanning electrodes, b_{1-1} to b_{1+1}, r_1, r_{1+1}, g_1, and g_{1+1} represent signal electrodes, and R_1, R_2, G_1, G_2, B_1, and B_2 represent sub-pixels (or sub-pixel electrodes). T_1 and T_2 are representatively shown.

(Problem to be Solved by the Invention)

However, in such a structure where active elements T_1 and T_2 are provided in each of the sub-pixel electrodes (R_1 and R_2), (G_1 and G_2), and (B_1 and B_2), twice as many active elements as the case of normal pixel electrodes having the integral structure are required, and therefore, it is necessary to provide six active elements for one picture element. If

the same area for one picture element is assumed in both cases, there is a problem in that an aperture ratio is reduced by three active elements per picture element in the case of the sub-pixel electrode structure as compared with the case of the pixel electrode structure having the integral structure.

In addition, in the case of the sub-pixel electrode structure, sub-pixels of the same color within a color pixel are positioned in a diagonal direction in order to reduce generation of moire fringes. In this case, as shown in a conventional display example of FIG. 3(A), when a letter A is for example displayed in monochrome with a 5 × 7 font size, sub-pixels emit light in black portions shown in the drawing and a horizontal line portion of this letter is visually seen so as to be disconnected in a diagonal direction. When this phenomenon is generated on an entire display screen, stripe patterns in the diagonal direction or in a certain direction are generated, and thus, it is difficult to see letters on the screen. Such difficulty in seeing the letters is not limited to the letter A, and there has been a problem in that such difficulty is generated in every case of displaying any letter having a horizontal line portion in monochrome.

It is an object of the present invention to provide a pixel electrode structure wherein even in a case of displaying any letter, figure, or the like having a horizontal line portion in monochrome, difficulty in seeing the horizontal line portion thereof is solved, an aperture ratio of one picture element region is increased, and colors can be mixed more easily than the conventional structure.

(Means for Solving the Problem)

In order to solve the problem, according to the present invention, a pixel electrode structure of an active matrix liquid crystal display device including plural sets of R, G, and B pixel electrodes individually driven by active elements, each of which is connected to mutually-perpendicular scanning electrode and signal electrode, and

including one picture element composed of one set of R, G, and B pixel electrodes, is characterized in that each of the R, G, and B pixel electrodes in each intersection portion of the scanning electrode and the signal electrode is formed to have a shape substantially protruding in a "boomerang" shape in an extending direction of the scanning electrode, and one active element is provided corresponding to each of the R, G, and B pixel electrodes.

According to an embodiment of the present invention, it is preferable that the shift amount in a protruding direction of a protruding portion having the "boomerang" shape of each of the R, G, and B pixel electrodes be set to any value in a range of 0.8 to 1.2 pixel pitch from either edge of each pixel electrode.

(Operation)

As described above, since each of R, G, and B pixel electrodes for forming one picture element is not segmented into sub-pixel electrodes and has an integral structure with a shape which is substantially bent in a "boomerang" shape, an aperture ratio is increased as compared with the case of the sub-pixel electrode structure. In addition, even when a letter is displayed in monochrome, generation of disconnection is not visually seen in a horizontal line portion of the letter by a protruding portion of the "boomerang" shape along the direction of a scanning electrode. Therefore, a display screen can be seen more easily and a mixed state of three colors R, G, and B becomes sufficient visually.

(Embodiment)

An embodiment of a pixel electrode structure of an active matrix liquid crystal display device of the present invention will hereinafter be described with reference to drawings.

The drawings cited in this embodiment described below are simply shown to understand the present invention, and the shape, the size, an

arrangement relation, and the like of each component part are not limited to those shown in the drawings.

FIG. 1 is an explanatory diagram of a color pixel electrode arrangement provided for description of a pixel electrode structure of an active matrix liquid crystal display device of the present invention and mainly shows one set of pixel electrodes forming one picture element when viewing an image display screen in a planar direction.

In the embodiment shown in FIG. 1, G_1 and G_{1+1} are scanning electrodes and r_j, g_j, and b_j are signal electrodes which are perpendicular to the scanning electrodes G_1 and G_{1+1}. R_j, G_j, and B_j respectively show one set of R, G, and B pixel electrodes, which are main component parts of the present invention, being bent in a "boomerang" shape and protruding in any one direction along an extending direction of the scanning electrodes. These pixel electrodes R_j, G_j, and B_j are respectively provided in intersection portions of the scanning electrode G_1 and the signal electrodes r_j, g_j, and b_j. The signal electrodes r_j, g_j, and b_j provided corresponding to these pixel electrodes R_j, G_j, and B_j are also bent in a "boomerang" shape similarly along these pixel electrodes so as to face them. In this embodiment, the protruding direction is set to a direction toward left in the drawing and each of the pixel electrodes R_j, G_j, and B_j substantially has the same shape. The width of each of the pixel electrodes R_j, G_j, and B_j in the direction along the scanning electrodes G_1 and G_{1+1} is the same. The sift amount in the protruding direction of the protruding portion with the "boomerang" shape of each of the pixel electrodes R_j, G_j, and B_j can be appropriately set according to a design. By forming the pixel electrode having a "boomerang" shape pattern as described above, when the liquid crystal display device is driven to display an image on a screen, letter components in the same direction as the extending direction of the scanning electrodes G_1 and G_{1+1} can be visually seen as a more natural image without disconnection as compared with the conventional case. In this case, it is preferable that the shift amount of the protruding portion be set to

any value in a range of 0.8 to 1.2 pixel pitch from either edge position of each of the pixel electrodes R_j, G_j, and B_j facing the scanning electrodes G_l and G_{l+1}. By setting the shift amount to the value within such a range, an image in a horizontal direction of a letter can be visually seen certainly as a more natural image so that the image can be seen easily.

In the embodiment shown in the drawing, the shift amount is set to one pixel pitch toward left of the drawing. Therefore, in this case, it is understood that the width of each pixel electrode becomes about 1/2 time and the length thereof becomes about twice.

Further, in the liquid crystal display device of the present invention, one active element for individually driving each of the R, G, and B pixel electrodes, such as a thin film transistor (referred to as a TFT) T_r, T_g, or T_b is provided for each of the pixel electrodes R_j, G_j, and B_j forming one picture element. The thin film transistors T_r, T_g, and T_b are preferably connected to the scanning electrodes G_l and G_{l+1}, the signal electrodes r_j, g_j, and b_j, and the pixel electrodes R_j, G_j, and B_j similarly to the conventional case so as to achieve functions thereof. Furthermore, I_r, I_g, and I_b are transparent conductive films of ITO or the like for electrically connecting each thin film transistor to each corresponding pixel electrode.

As set forth above, since one active element is provided for one pixel electrode, an aperture ratio per pixel, i.e., per picture element is increased as compared with the conventional one, a displayed image can be easily seen, and the resolution is improved. Although the thin film transistor is described as the active element in this embodiment, the present invention is not limited thereto and any other appropriate element having a switching function can be used.

Although the component parts only for one picture element are shown in the embodiment shown in FIG. 1, in fact, many intersection portions are formed in matrix by arranging many scanning electrodes and signal electrodes to be perpendicular to each other, and the above-described one

set of color pixel electrodes of R, G, and B for forming one picture element is provided in each of the many intersection portions arranged in matrix .

FIG. 4 is an equivalent circuit diagram having the structure shown in FIG. 1. In FIG. 4, T_r, T_g, and T_b are active elements and L is a liquid crystal. The component parts shown in FIG. 1 are denoted by the same reference symbols.

FIG. 3B is a diagram showing a pixel display example with the pixel electrode structure of the present invention. This display example shows an example of displaying a letter A with a 5 × 7 font size in monochrome like the case of FIG. 3A. As apparent from this display example, since disconnection in a certain direction is not generated in images of horizontal line portions of the letter, an entire screen can be easily seen. This is not limited to the letter A and the same can be applied for any other letter, figure, and the like having a horizontal line portion. It is assumed that since a protruding portion of a "boomerang" shape pattern of each pixel electrode is apparently close to an adjacent lighting pixel by visual illusion when an image is displayed, the displayed image is apparently seen easily.

Further, as apparent from this display example, even if an area of a pixel electrode is equal to the conventional one, the width of the pixel electrode is narrowed and the length thereof is increased by the pixel electrode structure of the present invention, and therefore, colors are visually mixed more easily and color images are recognized more preferably as compared with the conventional structure.

Moreover, moire fringes are not generated in displayed images by this pixel electrode structure, images displayed on an entire screen can be seen more easily as compared with a conventional pixel electrode arrangement in accordance with a conventional mosaic or stripe pixel arrangement.

(Effect of the Invention)

As apparent from the above descriptions, in the pixel electrode structure of the active matrix liquid crystal display device of the present invention, a pixel electrode for each pixel of R, G, and B forming a picture element is formed to have a protruding pattern which is substantially bent in a "boomerang" shape. Therefore, when a letter, figure, or the like having a horizontal line portion is displayed in monochrome, a line image in a certain direction is not disconnected. In addition, colors can be easily mixed. Consequently, the display screen can be visually seen more easily as compared with the conventional one.

Furthermore, since one appropriate active element such as a thin film transistor is provided for each pixel electrode, an aperture ratio is increased, and resolution is improved.

4. Brief Description of the Drawings

FIG. 1 is an explanatory diagram for describing one embodiment of a pixel electrode structure of an active matrix liquid crystal display device of the present invention;

FIG. 2 is an explanatory diagram for describing a conventional electrode structure;

FIGS. 3A and 3B are diagrams respectively showing display examples of an active matrix liquid crystal display device having a conventional pixel electrode structure and an active matrix liquid crystal display device having a pixel electrode structure of the present invention; and

FIG. 4 is an electrical equivalent circuit diagram of the pixel electrode structure of the active matrix liquid crystal display device shown in FIG. 1.

G_i, G_{i+1}: scanning electrode

r_j, g_j, b_j: signal electrode

R_j, G_j, B_j: pixel electrode

T_r, T_g, T_b: active element (e.g., thin film transistor)

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L: liquid crystal

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Amendment of Proceedings

January 27, 1989

To Commissioner of Patents, Mr. Fumitake YOSHIDA

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(1) In the line 2 to the line 3 on page 10 in the specification, "the width of each pixel electrode becomes about 1/2 time and the length thereof becomes about twice" is amended as "the width of each pixel electrode becomes about $1/\sqrt{2}$ time and the length thereof becomes about $\sqrt{2}$ time".